fied and extended. Without increasing its bulk, seventy-two new plates have been added; the text has been rewritten, and the maps revised to the date of issue.—"A Text-book of Shades and Shadows and Perspective," prepared for the use of students in technical schools, by Prof. John E. Hill, has reached a second edition. The book, which is published by Messrs. John Wiley and Sons, has been thoroughly revised and, in the main, rewritten.—Messrs. Cassell and Co. have commenced the issue of a cheap edition of their "Technical Educator." The parts will appear weekly, and each will contain ninety-six pages of text and illustrations.

The additions to the Zoological Society's Gardens during the past week include two White-thighed Colobus (*Colobus vellerosus*, ♂ ♀), a Campbell's Monkey (*Cercopithecus campbelli*, ♂), a Green Monkey (*Cercopithecus callitrichus*, ♂) from West Africa, presented by Dr. S. H. Armitage; a Lesser White-nosed Monkey (*Cercopithecus petaurista*) from West Africa, a Black-headed Lemur (*Lemur brunneus*) from Madagascar, presented by Miss Baird; an Arabian Gazelle (*Gazella arabica*, ♂) from Arabia, presented by Mr. R. G. Buchanan; two Raccoons (*Procyon lotor*) from North America, a Golden Eagle (*Aquila chrysætus*), a Buzzard (*Buteo vulgaris*), European, presented by Lord Arthur Cecil; two Laughing Kingfishers (*Dacelo gigantea*) from Australia, presented by Mr. F. Beaumont; five Eyed Lizards (*Lacerta ocellata*), European, presented by Mr. P. Goupille; a Thick-necked Tree Boa (*Epicrates cenchris*) from Tropical America, deposited.

OUR ASTRONOMICAL COLUMN.

Leonid Meteors in America.—The display of meteors on November 13 and 14 is said to have been great at some places in America. Published accounts include the statement that as many as twelve at a time were seen; and a press dispatch from Indianopolis states that meteors were visible there in broad daylight, in fact about the middle of the day.

A New Spectroscopic Binary in Puppis.—A new addition has recently been made to that class of stars of which ζ Ursæ Majoris, β Aurigæ, and μ' Scorpii are the present members. The star in question is Lacaille 3105, A.G.C.10534, and the Draper Memorial photographs show that it is a binary, its photometric magnitude being 4·50 (*Harvard College Obs. Circular*, No. 14). Prof. E. C. Pickering first noticed its binary character in February of last year, and this has been corroborated by several photographs secured by Prof. Bailey. A discussion of all the photographs taken, gives the length of the period as 3d. 2h. 46m., the formula representing the times of inferior conjunction being given as J.D. 2412777.16 + 3·115 E.

At these times the lines in the spectrum are said to be single; for the next thirty-seven hours they are double, the fainter component of each having a greater wave-length than the brighter component. The lines then again become single, and finally double for the remainder of the period, the fainter components having shorter wave-lengths, and being therefore towards the violet end of the spectrum.

Relative Motion in the Line of Sight.—In a *Harvard College Observatory Circular* (No. 13), Prof. E. C. Pickering describes a new method by which the relative motion of stars in the line of sight may be determined by means of the objective prism. As yet only preliminary trials of this method have been made, but it promises, as we are told, to be fairly satisfactory. In a discussion with Mr. E. S. King, of the experiments made by comparing the corresponding lines in the spectra of different stars with their images taken on another plate without the prism, and with the film reversed, the following process was evolved. It may be briefly summed up as follows. Two stars which are close enough to be photographed on a single plate are first selected. Let one of these be supposed at rest, and the other moving, say, towards the observer with a velocity represented by a deviation of amount *d* in its spectrum. If a photograph be taken such that the end of the shorter wave-length of the moving star be turned towards that of the star at rest, the distance between the images of a given line in the two spectra will be lessened by the amount *d*. By turning now the prism through 180°, the spectra will also be rotated through the same amount, and the end of greater wave-length of the spectrum of the moving star will now be turned towards that of the star at rest. If a photograph be taken in this position, the distance will in this case be increased by *d*. By superposing the two photographs thus obtained, making the images of the given line in the spectra of the star at rest coincide, the difference in the readings of the same line in the other spectra gives double the displacement of this line.

In actual practice the photographs can be obtained one on each side of the meridian, the act of reversing the telescope turning the prisms, and with them the spectra, through 180°.

For the examination of the plates, the film sides of the negatives must be placed together to ensure an accurate comparison, thereby necessitating that one of the photographs has to be obtained with the film side *away* from the objective prism. The question of change of focus can here then arise, of which, however, Prof. Pickering makes no mention.

The advantages of this method, as stated by him, may be condensed as follows:—Directness of the determination of the motion. Double the deviation is measured. Accidental errors of measurements are much less than when each in turn is bisected by a spider line, as the ends of two similar lines are made to coincide. Since each line in the spectrum may be used, a large number of independent determinations may be obtained from one pair of plates. Further, a visual telescope may be employed, as it is only *necessary* that one line should be in focus. Corrections for the motion of the sun in space, or of the earth in its orbit, may be disregarded, as they affect both stars equally.

Formulæ for computing Wave-lengths.—By the investigations of several workers the positions of the lines in the spectra of numerous substances are being mathematically determined. It was Lecoq de Boisbaudran who first pointed out the regularity in position in which lines of some substances appeared. Stoney, and others after him, found out that some of the lines of hydrogen were harmonically situated in the spectrum. It was left, however, for Balmer to bring forward a formula by which the wave-lengths of the lines in the hydrogen spectrum could be computed with wonderful accuracy. The formula was as follows:—

$$\lambda = A\frac{n^2}{n^2 - 4},$$

where n represented the numbers 3 to 15, and A the number 3645·42 in Ångström's units. Cornu at the same time, and Deslandres a year later, worked on this question, the latter producing a formula from which the bands of several elements could be computed.

In 1887 Kaiser and Runge set to work, and between them they advanced the new idea very considerably by describing a general formula which represented a great number of series of different elements, and which also included that of hydrogen, Balmer's formula being found to be only a special case. The new formula became then

$$\tau_n = A - Bn^{-2} - Cn^{-4},$$

the reciprocal of the wave-lengths (τ_n), instead of the wave-length themselves being here employed. The first three members of such a series sufficed to represent the series of lines with considerable approximation from values obtained from observation, with the exception, perhaps, of the longest and shortest waves. For the determination of these constants, which appear in this formula, three distinct measurements of the number of oscillations are necessary.

The drawback of this formula is that for the longest, or, at any rate, the two longest waves, it is not sufficiently accurate; and, even if more terms were added, the determination of the values of the additional constants would be uncertain owing to the limited accuracy of the wave-length measurements.

In determining the accuracy of this expression, Messrs. Kaiser and Runge were thus led to undertake the investigation of more accurate determinations of the spectra of the elements.

More recently, however, Herr Balmer has succeeded in finding an expression which represents the series with greater accuracy than formerly. This differs slightly from those given above, in that the third term is dispensed with, and an additional constant

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is placed in the denominator of the second term. The expression is

$$\tau_n = A - B/(n + c)^2.$$

That this is capable of giving results of very considerable accuracy is shown by its application in the case of the spectrum of helium, these results being given in the *Verhandlungen der Naturforschenden Gesellschaft in Basel*, Band xi. Heft 3, a "Separatabdruck" of which paper we have before us. All six series of lines in the spectrum have been computed, and in every case the differences, observed minus calculated, are small. Herr Balmer describes also a method by which the line series can be graphically constructed.

THE "LINCEI" AND EXPERIMENTAL SCIENCE.[1]

IN accepting the invitation to deliver an address on the twenty-first anniversary of the revival of this Academy, when it added social and philological science to mathematics and physical and natural science, I have from the outset not ignored the difficulty of my task, which I have since found even greater than I expected. Nevertheless, a consideration of the work done by the first Lincei, who founded this most ancient of all existing scientific Academies, and a notice of their contribution to the progress of all experimental sciences, particularly biology, appeared to me a subject worthy of your attention.

Federico Cesi, founder of the Lincei, leaving Rome in 1618, handed over to D. Virginio Cesarini, and Giovanni Fabri, Fellows, the mission of giving the ring of the Lincei to Carlo Muti. Cesarini subsequently wrote to Cesi that he had instructed the newly-elected Fellow in the usages and rules of the Academy, and "particularly in the liberty of conscience, love of truth, confession of ignorance, and also, so far as my poor intelligence can, I have not failed to open to him the true founts of human science, not dialectic but real, praising mathematics and natural science as the sole and only principles by which to gain knowledge in this world." The extract, which I have taken word for word, shows clearly the method by which alone the Lincei believed scientific truths could be sought out; and we should have known it more exactly but for the loss of a manuscript, by Cesi, on the "Universalis rationis speculum in quo universalis ars continetur." Still, we do know that at the first meeting, held October 15, 1603, Giovanni Eckio described the operation of the mind, by which it proceeds from facts to conceptions; that is to say, he spoke of induction.

The Lincei were not content with philosophising, but made experiments on subjects pertaining to natural and medical science; and set themselves to observe and calculate the motions of the stars. To this end they provided apparatus and instruments, including the telescope and the microscope, which latter they were the first to use, making known its advantages in the study of botany and zoology. The first print of a microscopic object is that by Francesco Stelluti, representing the honey bee, and placed as frontispiece to the *Apiarium* by Cesi, published in 1625.

The Lincei were also the first who instituted experiments to solve the question of the generation of living objects from putrefaction, an opinion then universally held. We find that Cesi was the first to recognise the animal nature of sponges, corals, and fresh-water polypi; that he maintained there was a gradual transition between the three natural kingdoms, and that he discovered fossil wood. For their method of pursuing science, the Lincei were persecuted from their very first meeting in 1603, and so bitterly, that they were obliged to separate and keep apart for several years. The Lincei had been preceded by Leonardo da Vinci, who held induction to be the only legitimate method in natural science; by Andrea Vesalio, who had overthrown Galen, insisting on the direct study of human anatomy; and by Niccolo Copernico, who subverted the Ptolemaic system, and established the sun as the centre of our planetary system around which the earth and other planets revolve.

On another side, the ground for scientific research had been prepared by the Florentine Platonic Academy, who had substituted Plato for Aristotle, and had grafted platonic idealism on the growing sentiment of Christian art. It was necessary, however, to free science from the spirits of the alchemists, from the idealism of the neoplatonists, from the teleological argument of the scholiasts; in a word, from every trace of transcendency and of finality, so that the human mind, being freed from prejudices and preconceptions, might be enabled, through the study of nature, and by the aid of mathematics, observation, and experience, to seek the real causes of phenomena. This was the work initiated by the Lincei, this was the innovation, deemed bold and dangerous, which gave rise to the new philosophy—Natural Philosophy—which in its turn originated the great scientific movement culminating in a Galileo, a Bacon, and a Descartes.

Galileo lived in the scientific atmosphere of the Lincei (to which Society he was elected in 1615), and he is held to be the founder of the experimental school, proceeding with steady steps in their ways, inventing valuable instruments, and making discoveries of the greatest scientific value. Bacon made no experiments, but gave instead the laws of induction; yet living among such surroundings as those of Elizabeth's court, then swarming with alchemists, notwithstanding his having combated their philosophy and that of the scholiasts with much minuteness, he still believed in spirits, and could not unfetter himself from final causes. Bacon has been accused of not appreciating with exactness the relation between cause and effect, not caring for mathematics, and supposing effects the results of one sole cause, which rarely occurs in nature. Purely inductive methods do not suffice for natural science, for when by them we arrive at one acquired truth, we can from this one deduce others by reasoning, and even rise by mental theories to more general principles. In this sense great credit is due to Descartes, who employed deductive methods, and exhibited the advantages in the study of nature arising from mathematics, as had been already recognised by the Lincei, and used by Copernicus, by Kepler, and, in conjunction with experimental methods, by Galileo.

To demonstrate the importance of the true causes which act on living organisms not solely from their exact value, we might adduce numerous examples taken from the progress made in our own time by medicine, the most practical and beneficent to humanity of all sciences; for if physics and chemistry have by their appliances increased the enjoyments of social life, medicine has succeeded in lightening many of the burdens of suffering humanity. The terror produced by the announcement of a great epidemic, when it was believed to be a chastisement sent from heaven to punish men on earth, ceased from the day when it was found to be the deleterious action of minute living objects, the so-called pathogenic microbes, and when aseptic and antiseptic cure, and the inoculation of attenuated virus and of curative serums were discovered to subdue and destroy the infinite armies of these imperceptible but deadly enemies to mankind, animals, and useful plants. I will not dwell longer on these and other victories of contemporary medicine, my only intention being to treat of science, which does not take account of utility, but is intent on discovering the causes of phenomena. If in practical life we must look to the good of humanity in science, there can be no special ulterior object of any kind. In medicine, however, as in every other science, we distinguish practice, or the application of scientific truths to the benefit of humanity, from science itself. Medicine reaps the benefit of the whole science of life, biology, of which morphology is an essential part, as well as that which seeks the true causes of organic forms in their origin, growth, and involution. Morphology, then, is called upon to solve the problems of organisation; for example, we desire to know why animals and plants leave their present form, in what way species differ or resemble one another, and in what relation they stand to their ancestors. The answer to such queries was at one time easy, but not scientific; when, that is to say, it was believed there was one pre-established type in which individuals were formed and species fixed, the answer was: that the form was what had been created, that consequently species were independent, that their ancestors had for their mission only to bear in their loins germs of such as they had been themselves, created contemporaneously with other matter in determined numbers, and with their form predetermined even to its minutest parts. With this doctrine research flagged, nothing was explained, and from the time of Gassendi (1592-1655), who was the first to formulate it, up to our present century, that is to say, till it was overthrown by the doctrine of evolution, our knowledge of living beings remained stationary. The science of the organisation of living beings, therefore, commenced when the theory of evolution became prevalent.

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[1] Abridged translation of an address delivered before the Reale Accademia dei Lincei, by Signor Todaro.

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